Acoustics, Ultrasonics and Vibration
National Measurement Institute, Australia (NMIA)
Brief Report

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The Acoustics, Ultrasonics and Vibration (AUV) group at the National Measurement Institute, Australia (NMIA) offers calibration services to both Australian and international clients, and undertakes ongoing research activities to expand and improve services.

Calibration services

Acoustics

Laboratory standard microphones are calibrated by the reciprocity method using a Brüel and Kjær (B&K) type 5998 Reciprocity Calibration Apparatus and a B&K type 9699 measurement chamber. The measurement chamber is coupled with an additional large-volume variable-pressure vessel to assist in minimizing the effect of fluctuations in the static pressure that may occur during non-stable environmental conditions. These calibrations are available as a public service but are mainly used for establishing traceability for our own reference microphones which are used in the calibration of microphones and microphone systems by comparison as well as for other equipment as discussed below.

Additionally NMIA continues to maintain and use an in-house 3-port reciprocity apparatus which was established in the 1980s and has been verified in international intercomparisons and is frequently re-verified as part of our routine calibration procedures. While the 3-port method is limited to frequencies below 1 kHz, it is quick and easy to perform, demonstrates high stability (we have a history of our Primary Standard Set of B&K 4144s going back to 1980), and it may be used with both 1″ and ½″ microphones.

The uncertainty of our standard reciprocity calibration of an LS1P test microphone is0.04 dB in the frequency range 50 Hz to 5 kHz, increasing to 0.08 dB at 25 Hz and at 10 kHz depending on microphone type. LS2P microphones may be calibrated to similar uncertainties (0.04 dB in the range 500 Hz to 8 kHz), but with a slightly larger dependency on frequency (0.1 dB at 20 Hz and 0.15 dB at 25 kHz).

Low-frequency microphones commonly used to monitor blast overpressures are calibrated by comparison with suitable reference microphones in a special coupler capable of completely enclosing both the test and reference devices. Such microphones can be examined at a suitable number of frequencies in the range 1 Hz to 250 Hz and at selected amplitudes. Using this apparatus, uncertainties are 0.4 dB for 1 Hz to 200 Hz. At the higher frequencies smaller uncertainties may be achieved by other methods.

For free-field measurements, NMIA maintains the free-field primary reference standard consisting of an LS2P capacitor microphone, which was initially calibrated by free-field and pressure reciprocity, and subsequently its sensitivity is regularly re-established by calibration using pressure reciprocity and its free-field sensitivity calculated using the pressure-to-free-field corrections given in IEC 61094-7. Free-field calibration of microphones is carried out in an anechoic chamber between 31.5 Hz and 20 kHz by substitution with a working reference microphone which is traceable to the free-field primary reference standard. Much of this work is done for instrumentation and special outdoor microphones used for environmental noise monitoring. Uncertainties range from 0.07 dB (160 Hz to 3.15 kHz) up to 0.14 dB at the lower (31.5 Hz) and upper (20 kHz) limit of the frequency range.

Pistonphones and acoustic calibrators are normally calibrated using laboratory standard microphones using an insert voltage technique. For pistonphones and acoustic calibrators that use other types of microphones, a substitution technique using a variable sound source is used. Calibrations are performed with reference to AS IEC 60942 (2004). Uncertainties are 0.07 dB to 0.09 dB in the frequency range 31.5 Hz to 8 kHz, and up to 0.23 dB at 16 kHz.

Vibration and ultrasound

NMI is mainly concerned with the calibration of reference-grade accelerometers and accelerometers that are used for precise or critical measurements of vibration. Most calibrations are performed either by comparison with the response characteristics of a calibrated NMIA standard, or by applying absolute measurement techniques through laser interferometry. NMIA's accredited scope permits uncertainties in the primary calibrations of 0.5% for 1 Hz to 20 Hz and above 6.3 kHz, 0.4% for 20 Hz to 63 Hz and 5 kHz to 6.3 kHz, and 0.3% for 63 Hz to 5 kHz; for comparison calibrations uncertainties are 0.5% for 20 Hz to 10 kHz, for accelerations of 10 m/s^2 to up to 5000 m/s^2. Typically an accelerometer is calibrated with its associated charge amplifier or power supply, comparing its voltage output with the acceleration measured with our standard or laser interferometer, for a number of frequencies and acceleration amplitudes. The normal units of this type of calibration are millivolts per metre per second squared ($mV/(m/s^2)$) or millivolts per standard g_n (mV/g_n, where g_n = 9.80665 m/s^2). Charge accelerometers can also be calibrated without a conditioning amplifier; in this case the sensitivity of the accelerometer is expressed in picocoulombs per metre per second squared or per g_n, ($pC/(m/s^2)$ or pC/g_n). Vibration meters and monitors are calibrated in a similar way.

Horizontal and vertical omni-directional, and uni-directional velocity transducers and geophones may be calibrated up to a frequency of 250 Hz. In NMIA's present system the limitation of mass for vertically orientated transducers is 0.5 kg, and horizontal transducers is 5 kg. Velocity transducers are usually calibrated against NMIA's reference accelerometers. The normal calibration units of geophones and other velocity transducers is the millivolt per millimetre per second (mV/(mm/s)).

Calibration of accelerometers with charge amplifiers set to provide an output proportional to velocity, can be calibrated as an accelerometer. The units of this type of calibration are mV/(mm/s).

NMIA also performs calibrations of portable calibration exciters, shakers, electronic filters, conditioning amplifiers, attenuators, and sound level meters. NMIA has also recently established a primary calibration system (provided by NPL) for ultrasonic power meters. The range of operation of this instrument is 1 MHz to 15 MHz, 10 mW to 20 W. Estimated expanded uncertainties are between 3% and 8%, depending on the power range.

In the last two years NMIA has provided, on average, over 150 calibrations per year for clients in Australia and the region. Of these calibrations approximately 51% were for microphones, about 21% for accelerometers, 17% for acoustic calibrators and pistonphones, and 11% for other instrumentation such as charge amplifiers, attenuators, geophones, etc.

Present Development Activities

The recent changes in staff have provided the opportunity to reassess many of NMIA's procedures and services. We are concentrating on improving the uncertainty evaluations in many of our most-used procedures. For example, in our calibrations where a number of measurements are taken under certain conditions, and then this is repeated several times after disassembly and reassembly, the use of a pooled-variance approach to estimating Type A uncertainties is under discussion. The analysis of uncertainties in NMIA's comparison vibration calibrations is the initial application for this method.

As funding allows, we are embarking on the establishment of a new primary interferometric vibration standard with a view to expanding its use into new calibration services.

Following installation and testing of our new ultrasonic power standard, NMIA aims to have this service accredited by NATA (the National Association of Testing Authorities).

Early in 2010 NMIA acquired the hardware to establish a new service in the calibration of artificial mastoids. The development of a procedure traceable to SI units of measurement, including uncertainty estimates, is presently underway and we hope to offer this service in 2011.

Staff

Dr Andrew Scott has been appointed the new Group Leader of the AUV group at the NMIA, replacing Dr Prem Narang in February 2010. Mr Laurence Dickinson will also be joining the group in October 2010, and will be primarily working in vibration standards. Mr Trevor Bell is primarily responsible for our acoustics work.